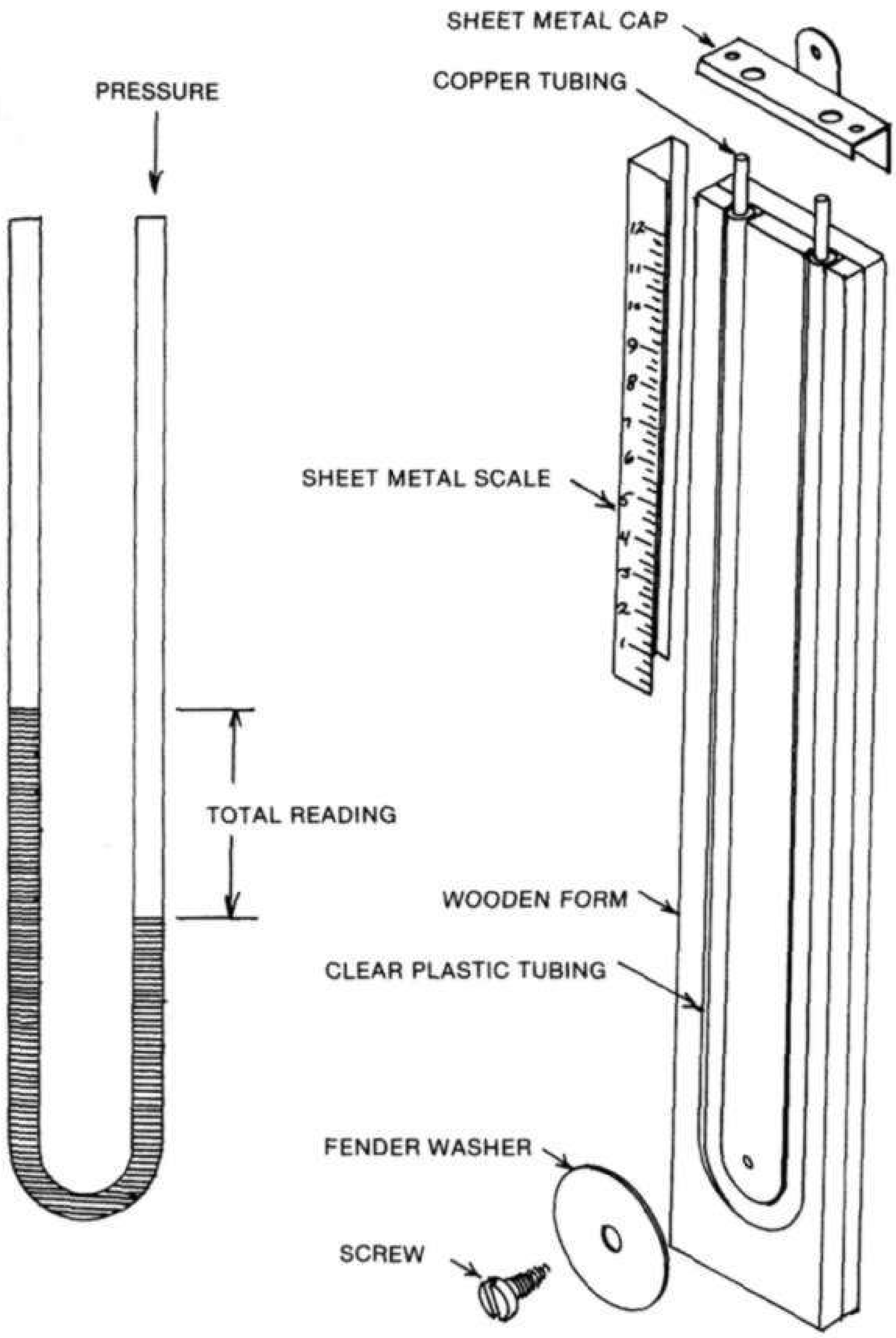
THE "U" TUBE MANOMETER

Although fans can be built to deliver very high pressures sometimes needed by industry, most fans develop low pressures, usually below one pound per square inch. Mechanical gauges are available to indicate these low pressures but they are very costly. Most of us could not justify even a moderately priced gauge for the home shop. Fortunately, an expensive gauge is unnecessary. A simple manometer will do.

A "U" tube manometer displays the effect of pressure on a column of liquid within a transparent tube. When the tube is filled with water, it is called a "water gauge." One ounce of pressure will raise the water column 1.73 inches. If the tube were filled with mercury which is much more dense than water, the same one ounce of pressure would raise the mercury column just .127 inches. Water is obviously the correct gauge liquid for our low pressure needs.

A manometer is simply a transparent tube that is formed in the shape of a "U" and that is partially filled with water. When pressure is applied to either leg of the gauge, the water is forced down in one leg and up an equal amount in the other. The difference between the level of the water in both legs provides a reading of the pressure applied.

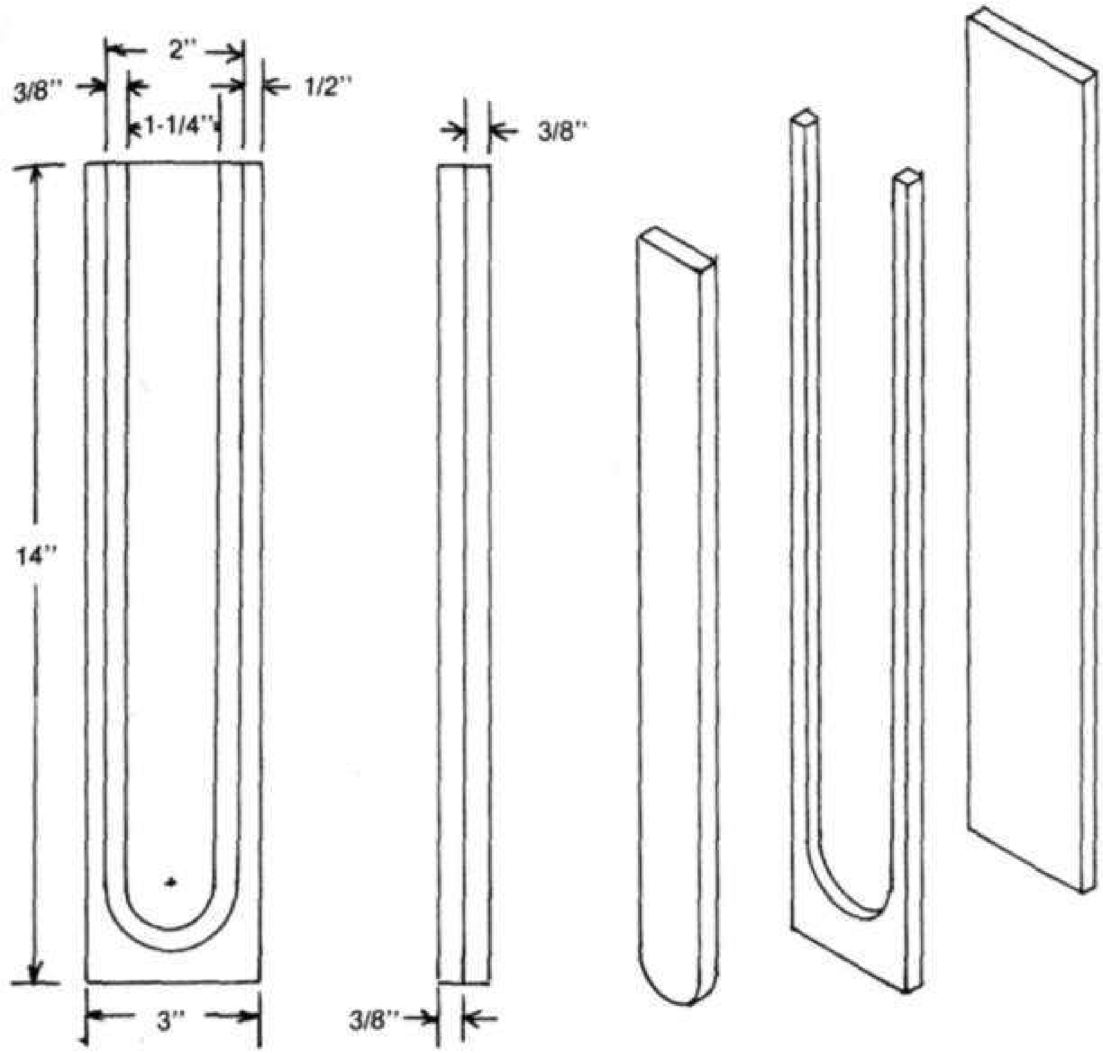
A simple direct reading scale can be prepared by mounting a scale of sequentially numbered marks at 1/2" intervals next to one leg. A half-inch rise in one leg would be a 1" difference since the other leg will move a 1/2" in the other direction.


PRESSURE
TOTAL READING
SHEET METAL CAP
COPPER TUBING
SHEET METAL SCALE
WOODEN FORM
CLEAR PLASTIC TUBING
FENDER WASHER
SCREW

A very durable and accurate water gauge can be made with clear plastic tubing and other common materials. Most commercial manometers use a tube with an internal diameter of 3/16" to 1/4" although other sizes are sometimes used. Inexpensive clear plastic tubing with a bore of 1/4" and an outside diameter of 3/8" is readily available in most hardware stores. Not only does it make an excellent gauge, but it also serves as a convenient connecting hose to the pitot tube or the gauge port in the fan system.

It is important to minimize distortion in the "U" bend of the manometer. Since plastic tubing is soft and flexible, it requires an accurately-made mounting to mold the bend and to hold the legs erect. With 3/8" thick wood and simple hardware, a mount can be built that provides a uniformly shaped channel of 3/8" width into which the tubing can be pressed.

All of the elements of a water gauge are shown in the drawing on page 65. The wooden form provides a snug channel into which the tubing is pressed. A fender washer and wood screw hold the tubing in place at the bottom end while a simple sheet metal cap with holes for the 1/4" copper tubing holds the manometer tube in the mount. In addition to anchoring the manometer tube in the mount, the copper tubing also provides a convenient connection for the hose to the pitot tube or test port. A simple scale marked out on sheet aluminum that is bent around the body of the mount to a snug sliding fit enables you to "zero" the gauge before use. If each numbered increment is 1/2" then the readings indicated are 1" of water column.



Dimensions for a wooden form are suggested on page 67. Although a 3/8" channel could be routed out, it is probably easier to make the form in 3 pieces and join them with brads and glue. A coat of clear varnish just before the tube is finally pressed in will make the whole unit more durable and attractive. A small amount of food coloring in the water makes the column more visible. Although laboratory practice sometimes calls for distilled water to be used, our colored tap water will not affect the accuracy of our casual measurements.

The readings of the manometer in inches of water column are converted to ounces per square inch by dividing by 1.73. A scale can be prepared to read directly in ounces per square inch with major divisions at 55/64" intervals since 1.73" of water column is equal to 1 ounce per square inch. The readings in ounces per square inch are converted to inches of water by multiplying by .58.

$$\frac{1.73''}{2} = .865'' \doteq \frac{55}{64} \text{ inches (approx)}$$

$$= \text{a 64th short of } 7/8''$$

(You must divide 1.73 by 2 because one side of the manometer rises while the other falls. The difference between .865 and 55/64 is about .006"—insignificant in our work.)

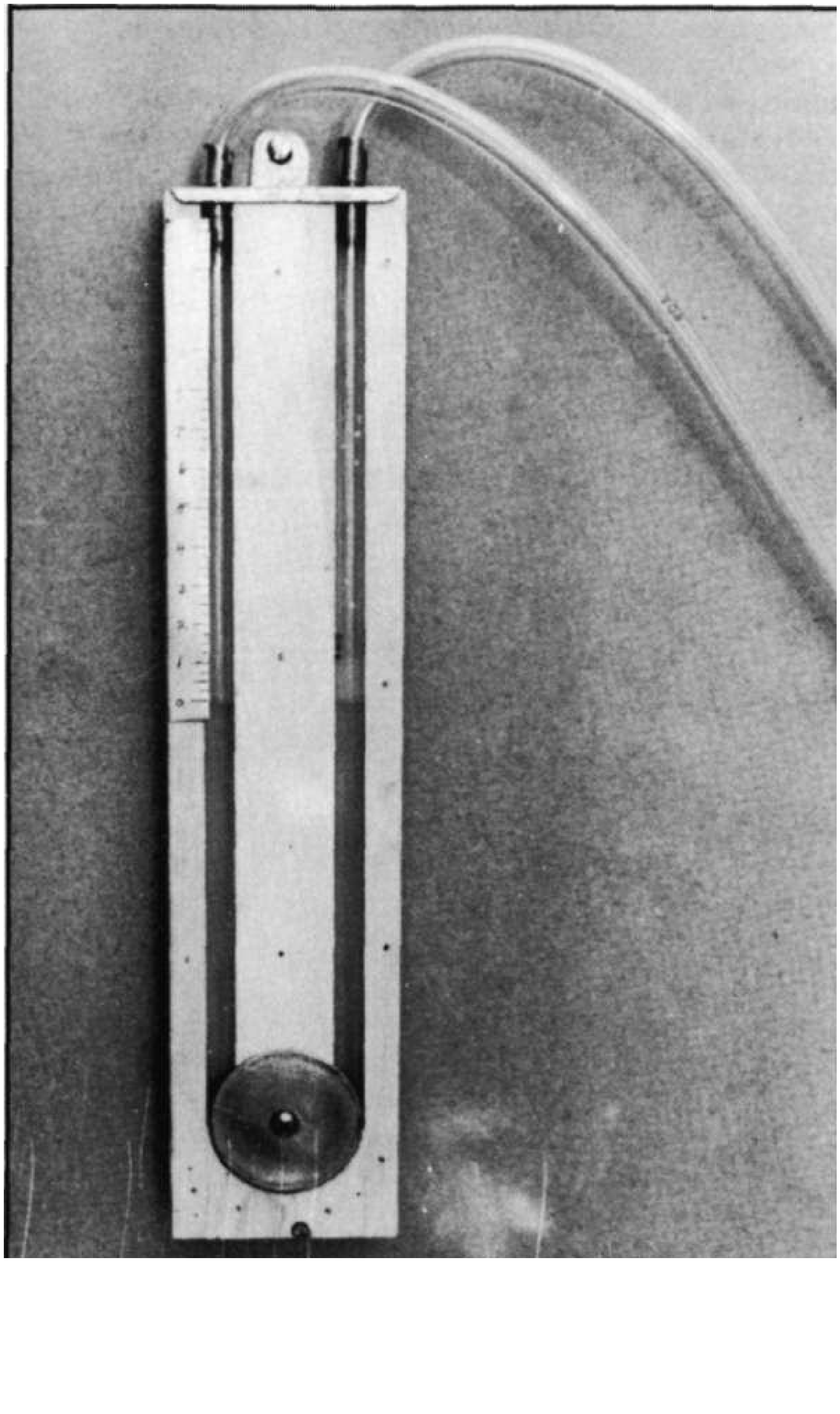
MEASURING PRESSURE

Soon after you build the manometer, you will discover how sensitive it is. If you connect a hose to either leg and blow gently at the end of the hose, the opposite column will rise. Although some commercial manometers are graduated finely enough to read even very tiny pressures, we need not be concerned with anything finer than 1/8" water column.

We have already discussed the three types of pressure found in a fan system: velocity pressure, static pressure, and dynamic pressure. Of these, velocity pressure is the most useful for design work.

While the dynamic pressure is the source of both static and velocity pressure, its measurement is of very little use to us in testing. Since dynamic pressure acts only in the direction of flow, you can read it by merely connecting a hose to the manometer and placing the opposite end squarely into the air stream. This will be the highest reading in the system since it indicates the total pressure.

Static pressure is the result of resistance to the dynamic pressure, and it acts in all directions. It can be read directly by placing the test hose anywhere in the system where it will not receive the forward pressure of the stream of air. The reading is normally taken from a tap in the duct that is at right angles to the stream and where no obstruction might deflect the stream into the tap.



Dynamic pressure minus static pressure is velocity pressure. When one leg of the water gauge is connected to a port to read dynamic pressure and the other leg is connected to a port to read the static pressure, the velocity pressure can be read directly from the manometer. The static pressure and dynamic pressure oppose each other. The difference, velocity pressure, is, in a sense, calculated within the gauge.